Designing a centring mechanism and stacking machine for doors

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Bridging programme for Master of Electromechanical Engineering Technology

Introduction

Our integrated project is conducted at Theuma, a prominent European manufacturer of door sets, employing 250 individuals across its facilities in Belgium and the Netherlands. Specializing in the design, production, sale, and assembly of ready-to-use door sets. Theuma caters to both residential and non-residential construction projects of various scales [1].

The production process starts with the fabrication of the frames to precise specifications, embedding a chip to relay necessary instructions to subsequent machinery. After this only automated processes take over, seamlessly executing each step. Initially, infill material is inserted into the frame, followed by the application of two cover plates, which are then cured in an oven. Doors are trimmed to exact dimensions next, with optional milling of the sides. A plastic strip of matching colour is applied to the long sides for a uniform appearance. Doors then proceed to the paint line to apply the final finish. Each door passes through the lacquer line twice to paint the top and bottom using paint rollers, followed by rapid curing via UV light or electron irradiation.

The production process ends by sending the outgoing doors to a pallet-stacking gripping machine via transport rollers. **This integrated project focuses on optimising this mechanism.**

Objectives

The objective is to centre the doors towards the middle of the conveyor belt and stack them in such a way that the centrelines of the doors align vertically. To achieve this, a centring mechanism and a stacking machine will be designed. Before beginning the design process itself, the requirements to be met by the mechanisms are first established. The requirements are divided into several categories. They consist of fixed requirements, variable requirements and wishes. These requirements are summarized in Table 1.

Table 1: Requirements

Fixed requirement	Variable requirement	Wish	Requirement description
x			The door must be centered during transport to the gripper.
x			Transportation of the door should not damage the door if the door shifts.
x			Transport keeps moving while the door is centered.
	x		The cycle time should be between 6 and 8 seconds.
x			Centering should be sensor controlled.
	x		Active hours of the machine are 2 shifts (8 hours) per day, 5 days a week.
x			Fixed mount to existing structure.
x			Avoid clamping hazard due to safety.
x			Must be able to work completely autonomously
x			Material selection such that the machine can last > 20 years
x			Gripping mechanism must not damage the door.
x			Width of centering mechanism is 1400 mm.
	x		Must be able to handle doors 530-1130 mm wide and 1750-2600 mm long.

Problem definition

Theuma encounters a significant issue when stacking the doors at the end of the production line, as they stand unstable on the pallets. This instability arises from stacking the doors based on their lateral sides, where variability in width plays a crucial role.

Thus, if a narrower door is placed at the bottom of the stack, there is a risk of the stacked doors toppling over due to external factors. Figure 1 illustrates this problem by depicting a narrow door at the bottom. However, this stack of doors will be 1.5 m higher.

Figure 1: Unstable stacked doors

Methodology

To bring the integrated project to a proper conclusion, we started by **visiting** the company several times to consult our coordinating manager. Working with him, the requirements package was put together (see Table 1) and the rough dimensions of the future machine were defined. Given the project's nature as an enhancement of an existing mechanism, these dimensions are very important. With this information, a **function block diagram** could then be compiled, outlining the sequential processes essential for the door movement to its final destination. Displayed in Figure 2. With these different steps in mind, a **morphological diagram** was constructed. This diagram gives multiple solution strategies for each production step in order to connect the most efficient way to build the machine. After this, sketching on paper could start of certain moving mechanisms, starting with the centring mechanism, see Figure 3. The **CAD-software** CREO Parametric was then utilized for the comprehensive development of the machine in both 3D and 2D representations.

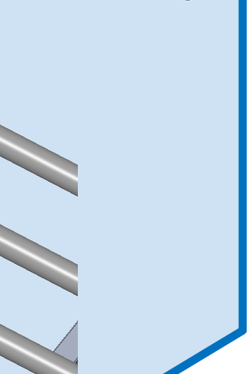
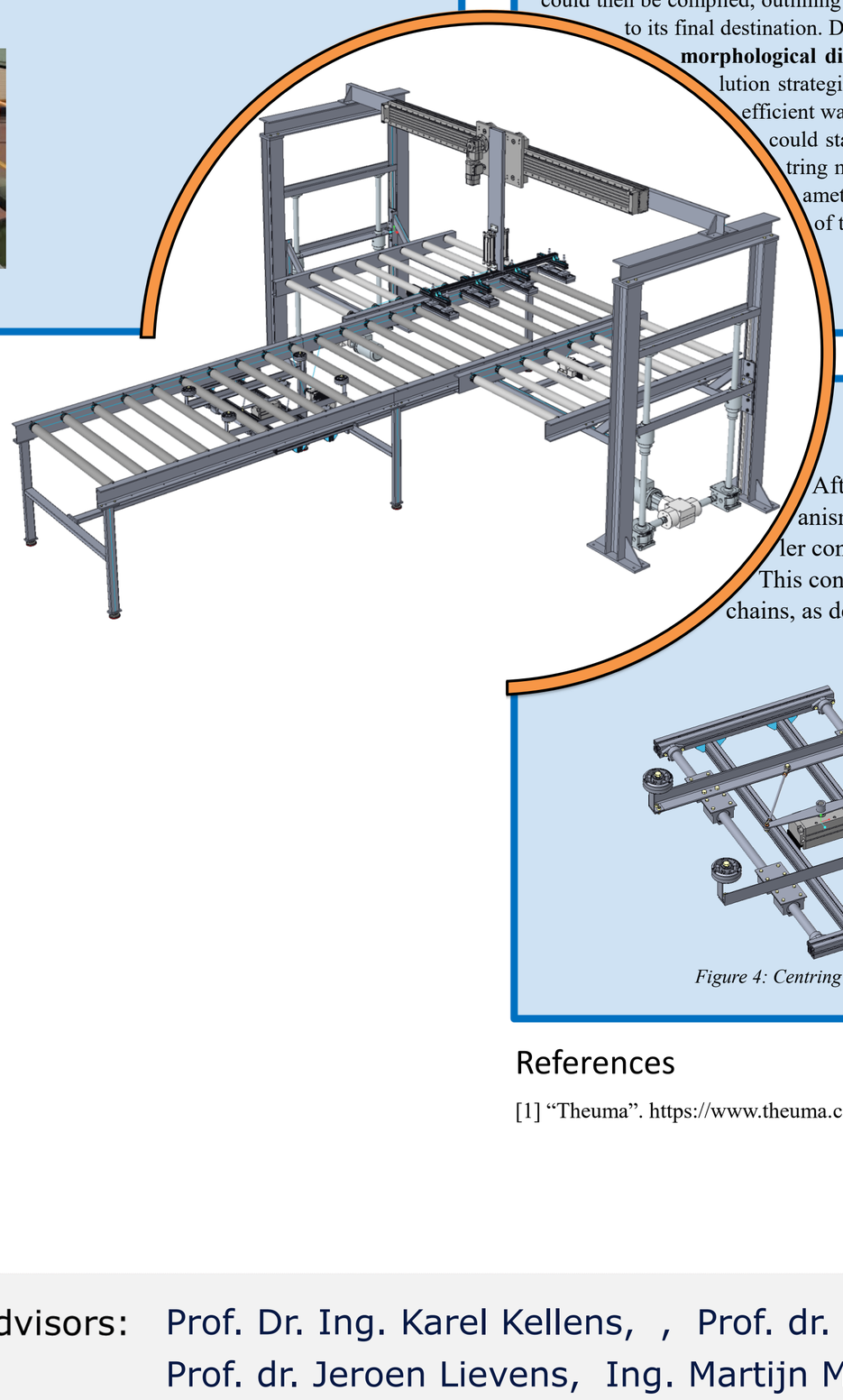


Figure 3: Sketches of centring mechanism

Figure 2: Function block diagram



Results

After the completion of the concept drawings on paper, the centring mechanism was drawn in CREO, as depicted in Figure 4. Following this, the roller conveyor for transporting the doors to the gripping machine was designed. This conveyor system is powered by an AC motor linked to each roller through chains, as demonstrated in Figure 5.

Figure 4: Centring mechanism

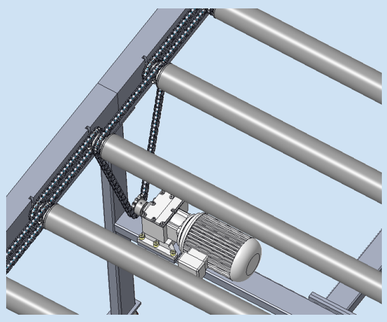


Figure 5: Motor driven roller conveyor

References

[1] “Theuma”. https://www.theuma.com/theuma/ (accessed Nov. 23, 2023).

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